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WEAK LINKS WITHIN A $Bi_2Sr_2Ca_1Cu_2O_x$ SINGLE CRYSTAL BY MAGNETIZATION AND DIRECT OPTICAL OBSERVATIONS

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We have performed magnetic susceptibility and direct optical High Contrast Magnetic Flux (HICOM) observations on a single crystal of $Bi_2Sr_2Ca_1Cu_2O_x$. Low temperature pinning and high temperature flux creep have been observed by HICOM. The results suggest that the breakdown of flux pinning may occur gradually with temperature and may exhibit spatial variation related to sample inhomogeneities.

1. INTRODUCTION

The understanding of magnetic flux pinning, of flux creep, and of the completed breakdown of pinning at the irreversibility temperature T_{irr} far below the superconducting transition temperature T_c in Bi cuprate-based superconductors[1] is important both for the fundamental mechanism of superconductivity and for practical applications. Therefore, we have investigated these properties in a single crystal of $Bi_{2.2}Sr_{1.8}Ca_1Cu_2O_x$ (Bi2212) by magnetization and by a direct optical method, which permits the acquisition of the spatial variation of magnetic flux.

2. EXPERIMENTAL

Single crystals of $Bi_{2.2}Sr_{1.8}Ca_1Cu_2O_x$ (Bi2212) were grown by a traveling solvent floating zone (TSFZ) technique that is described elsewhere[2]. The crystal examined in this work was approximately 1.6 x 1.3 x 0.03 mm, the large surface being parallel to the *ab* plane.

Magnetic susceptibility measurements were carried out in a Quantum Design Model MPMS SQUID magnetometer with the magnetic field oriented along the crystallographic *c* axis.

The high contrast observation method for magnetic flux density[3] (HICOM) optically monitors the flux distribution in a superconductor by observing changes in the polarization of the domains in a ferrimagnetic rare-earth iron garnet film placed in contact with the sample.

3. RESULTS

The susceptibility results as measured at 10 Oe show a T_c onset at 87 K and a ≈40% Meissner volume fraction. Magnetic hysteresis is large below 10K, but decreases rapidly and vanishes above 30K. The magnetic relaxation data at 10K (not fully penetrated by flux at 1760 Oe) and 15K data show a logarithmic decay; the data for 20K and 25K start off logarithmically, but then change to a slower time dependence. The magnetization at 30K, we believe, has already decayed significantly by the time the first data point was taken, and is thus already in the long time limit. This behavior has been reported by Xu et al.[1] for Bi2223. Because of the very rapid relaxation at this relatively high temperature, it is also possible that the sample is never really in the critical state as has been recently analyzed by Griessen[4].

Figure 1 shows a photograph of the HICOM image of the crystal zero field cooled to 15K after which a field of 1760 Oe has been applied and

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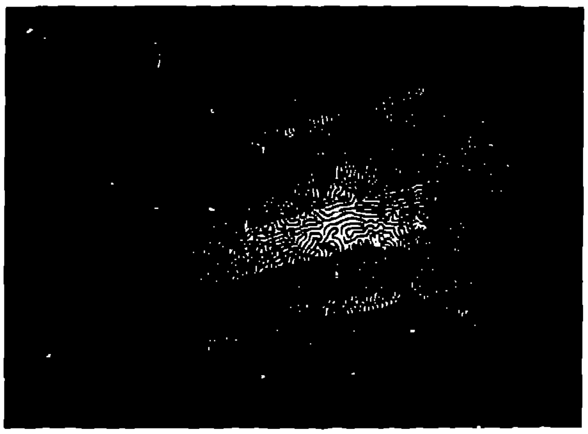

Figure 1
HICOM photograph of the Bi2212 crystal at 15K. The sample was ZFC, then H was increased to 1760 Oe and decreased to 0 before photography.

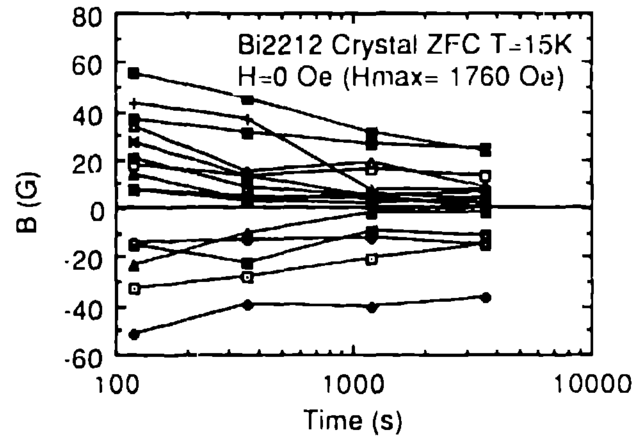

Figure 2
Magnetic flux B vs. time for several points across the face of the Bi2212 crystal from top to bottom. These data were taken from HICOM pictures.

removed. It is clear that the flux penetration is not uniform and in fact reflects variations in the pinning strength in the crystal. Figure 2 is an analysis of the data of Fig. 1 and additional data showing the field distribution across the sample as a function of time. Although the number of data points as a function of time is small, in general, a rapid initial relaxation decays to some long-term value that is a strong function of the initial value.

4. DISCUSSION

We can compare the relaxation measurements by magnetization and HICOM and find qualitative agreement. What is clear from the HICOM data is that the breakdown of flux pinning is nonuniform over the area of the crystal. Effectively, there is a range of T_{irr} within this crystal. From our work it is not yet clear whether this is a general feature of Bi2212 or specific to this sample. However, it is likely that for any crystal, as the average T_{irr} is approached, variations in pinning will be accentuated, and that a state like that shown in Fig. 1 will result.

5. CONCLUSIONS

We have observed variations in pinning strength within a Bi2212 single crystal, and have monitored flux creep in this material by a direct observation technique. It is suggested that after this initial work, the HICOM technique may be able to isolate areas of relatively strong and weak pinning, and that these areas may be examined further by other techniques to determine the source of the weaknesses with a goal of improving the properties of this material.

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REFERENCES

1. Y. Xu and M. Suenaga, Phys. Rev. B43 (1991) 5516.
2. K. Takamuku et al., Bi2212 phase crystal growth, this volume.
3. S. Gotoh et al., Jpn. J. Appl. Phys. 29 (1990) L1083.